U. S. DEPARTMENT OF AGRICULTURE - FOREST SERVICE
CALIFORNIA FOREST AND RANGE EXPERIMENT STATION
Division of Forest Insect Research

Progress Report

RESISTANCE OF PINES AND PINE HYBRIDS TO THE REPRODUCTION WEEVIL

1956 Season

By Richard H. Smith

SUMMARY

Work was continued on determining the resistance of pine species and hybrids to *Cylindrocopturus eatoni*. The general procedures developed by J.M. Miller were used at the Institute of Forest Genetics at Placerville. From forced-attack tests the three-way hybrid of J x (J x Cl) x P (Jeffrey x (Jeffrey x Coulter) x Ponderosa) appears to be as resistant to weevil attack as the J x (J x Cl) hybrid which has performed so well in field tests.

From the natural infestation in the nursery, the high susceptibility of Apache and Montezuma pines and their hybrids with ponderosa and Jeffrey was clearly shown.

Little of a conclusive nature could be ascertained about the relative susceptibility of the progeny from various ponderosa and Jeffrey pines.

Other highly susceptible hybrids of pines, as indicated by the natural infestation in the nursery are *P. Murryana* x *P. banksiana* and *P. nigracalabrica* x *P. thumbergii*.

The season's work suggests: (1) continued screening of species and hybrids, (2) more effort devoted to forced-attack tests, and (3) possible changes in the design of planting for more conclusive interpretation of results.

Introduction

In 1946 J. M. Miller started research on the resistance of pines to the reproduction weevil *Cylindrocopturus eatoni* Buchanan. Work was carried on rather continuously until 1952. For the next three years the work was considerably reduced. This report covers the results of the studies conducted in 1956 when work was resumed as part of the plant resistance research carried on by the Division of Forest Insect Research of the California Forest and Range Experiment Station. Much of Miller's early work is presented in a well-illustrated publication[1] which contains the basic information on the insect-plant relationship. There has been subsequent work which was largely a screening of additional species and hybrids of hard pines.[2]

There are many important aspects to Miller's work but no attempt will be made to present them here. The highlights of his studies are the resistance of Coulter pine to the weevil, the general susceptibility of ponderosa and Jeffrey, and finally the resistance of the J x (J x Cl) hybrid.

Procedure

The 1956 tests were conducted according to the procedures developed by Miller. Infested material was collected in April from the Shasta-Trinity, Eldorado, and Stanislaus National Forests, and the Institute of Forest Genetics at Placerville. At the time of collection the weevil was in the overwintering stage, a fully developed larva in the wood of 3- to 10-year-old trees killed the previous year. All the material was heavily infested.

On May 18 a large cage (fig. 1) was placed over the section of the 1953 nursery bed which was to be tested and the infested material was placed among the 3-year-old seedlings. These were in rows 6 inches apart, with 6 inches between plants within the row. There were 10 or less seedlings in a row. Each row consisted of the progeny of a single cross and the various plant combinations in a single experiment block were randomly assigned to rows. The plant of most interest was a three-way hybrid of ponderosa, Jeffrey, and Coulter pine. Ponderosa and Coulter will not hybridize with each other but both will cross with Jeffrey. The three-way hybrids resulted from the pollination of a Jeffrey x (Jeffrey x Coulter) with ponderosa.

Emergence of the weevils in the cage started in early June and increased rapidly through June and early July. They completed their adult activity by late August. Needle-feeding punctures became numerous in late June, though there was practically no sign of stem punctures as indicated by resin globules. By mid-July stem resin globules, indicating oviposition, were abundant and by late August some plants started to fade. During the periodic observations it

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1/ Miller, John M. 1950. "Resistance of Pine Hybrids to the Reproduction Weevil." For. Res. Note #68. Calif. For. & Range Exp. Sta., Berkeley, Calif.

2/ Ibid., 1950 "Studies of Resistance of Pine Hybrids to Insect Attack at Institute of Forest Genetics" Unpub. Report, Forest Insect Laboratory Nov. 1950, Berkeley, Calif.

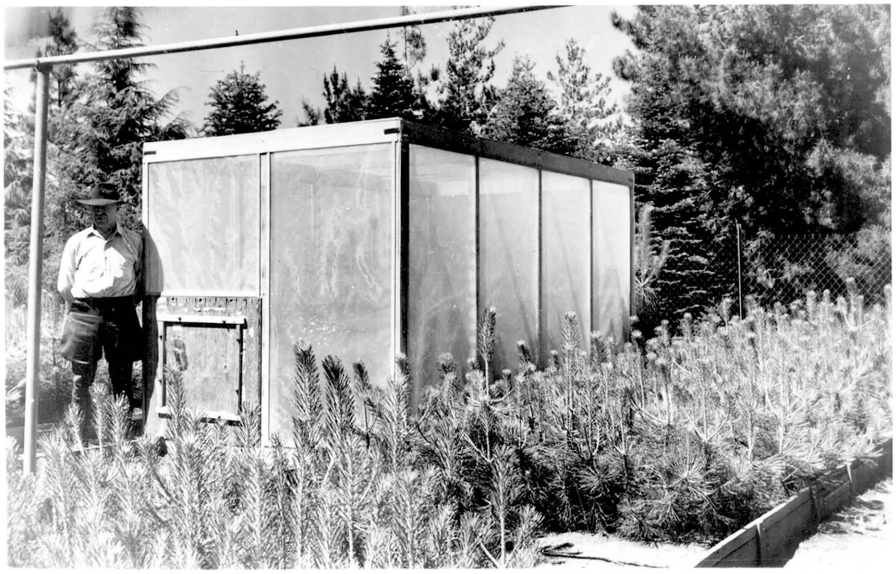

Fig. 1.--Portable cage enclosing section of nursery bed to be exposed to forced attack of *Cylindrocopturus eatoni*.

was apparent that the weevil population within the cage was exceptionally heavy and that the test would be a very severe one for the seedlings.

In September the cage was removed and a preliminary examination made of mortality. However, since many trees were still in a questionable condition, the final examination was not made until May 1957. The data obtained were not detailed, being only a recording of mortality and the presence of needle and stem punctures. At this same time in May 1957 the incidence of mortality caused by the natural infestation outside the cage in the nursery was also recorded. The interpretation of mortality under these conditions is quite difficult because of the spotty pattern of the natural infestation. However, general ratings of species and hybrids can still be made.

Results

The results are summarized in the three tables which follow.

In table 1 are the results of the forced attacks within the cage (fig. 1). The rows of 1a and 1b were randomly assigned to a stretch of a nursery bed and the adjoining stretch contained 2a, 2b, and 2c, also randomly assigned. Therefore, all rows of plant combinations were not fully randomized within the nursery bed area covered by the cage. However, under these conditions all plants in the cage were, presumably, exposed to the same intensity of weevil attack. It will be noted that the same J x w is represented in the two blocks within the cage and that the mortality was about the same, 1a and 2c.

Table 1.--Forced attacks by C. eatoni on 3-year-old seedlings

Block		Plant combination1/	Trees	Mortality
			Number	Percent
1	1a	Jeffrey x wind	34	91.2
	1b	Jeffrey x Coulter	25	48.0
2	2a	Jeffrey x (Jeffrey x Coulter) x ponderosa	38	47.4
	2b	Ponderosa x wind	39	48.7
	2c	Jeffrey x wind	46	93.5

1/ The pollen source is to the right of the x.

Table 2.--Natural infestation by C. eatoni on 3-year-old seedlings

Block		Plant combinations1/	Trees	Mortality
			Number	Percent
1	1a	Ponderosa x (Apache x Montezuma)	32	81.3
	1b	Ponderosa x wind	34	2.9
2	2a	Ponderosa x Apache	29	96.6
	2b	Ponderosa x wind	50	54.0
3	3a	Ponderosa x Montezuma	20	70.0
	3b	Ponderosa x wind	46	28.3
4	4a	Ponderosa x Apache	35	38.9
	4b	Ponderosa x wind	46	13.0
	4c	Ponderosa x Montezuma	43	32.6
5	5a	Ponderosa x Apache	57	36.8
	5b	Ponderosa x wind	55	31.0
	5c	Ponderosa x Montezuma	38	28.9
	5d	Apache x Montezuma	36	91.7
6	6a	Murryana x banksiana	32	53.1
	6b	Murryana x wind	3	0.0
	6c	Murryana x wind	46	47.8

1/ Maternal parent x paternal parent.

Table 3.--Natural infestation by C. eatoni on 2-year-old seedlings

Block		Plant combinations[1]	Trees	Mortality
			Number	Percent
1	1a	Jeffrey x (Jeffrey x Coulter)	39	10.3
	1b	Jeffrey x (Jeffrey x Coulter)	38	13.2
	1c	Jeffrey x (Jeffrey x Coulter)	35	20.0
2	2a	Jeffrey x (Jeffrey x Coulter) x Apache	28	25.0
	2b	Ponderosa x wind	26	4.0
	2c	Jeffrey x wind	30	3.5
3	3a	Nigracalabrica x thumbergii	30	53.3
	3b	Nigracalabrica x wind	25	0.0
4	4a	Nigracalabrica x thumbergii	45	77.8
	4b	Nigracalabrica x wind	44	6.8

1/ Maternal parent x paternal parent.

The data in table 2 were secured from various sections of the 3-year-old nursery and represent mortality caused by the natural weevil infestation. From one block to another does not represent a continuous stretch of nursery bed area. The rows within a block, occupying the approximate same area, can be assumed to have been exposed to approximately the same weevil population. Between blocks no such assumption can be made. Within a block in every case the ponderosa parent is the same for all combinations. Between blocks the ponderosa parent was usually different.

Table 3, like table 2, represents the mortality caused by the natural weevil population in the nursery. However, the seedlings were only 2 years old. Blocks 3 and 4 are the same combinations in different areas of the nursery. In block 1 the (J x Cl) pollen source was the same, while the (J) cone source was different.

Discussion and Conclusions

1. The trihybrid of Jeffrey, ponderosa, and Coulter is as resistant to weevil attack as the Jeffrey x (Jeffrey x Coulter) hybrid (table 1). The latter has been tested in the field and has demonstrated excellent resistance under these conditions. Therefore, it might be assumed that the three-way hybrid will perform equally as well. The rather heavy mortality of both these combinations in the test can probably be explained by the very heavy population of weevils contained within the cage. The 90+ percent mortality of the Jeffrey pines is an indication of the intensity of the attack. All trees which survived

were heavily attacked. The needle punctures were exceptionally numerous on all plants, so much so that the defoliation effect was a remote possibility.

2. The almost-identical mortality of the same Jeffrey x wind, 1b and 2c, in the two different blocks in the cage suggests an even distribution of the weevil attack.

3. It is difficult to adequately explain the heavy population in the test. The quantity of infested material was about equal to that used by J.M. Miller in similar tests. There was no measure of the actual number of weevils which emerged. The number of weevils which emerge from a unit of infested material could have been far more than that in previous tests. Also, the general level of weevil activity was high in other parts of the State in 1956.

4. The introduction of either Montezuma or Apache pine into ponderosa greatly increases the weevil-caused mortality in such plants. If the various combinations of these trees in table 2 are totaled, the mortality is as follows: P x w = 38 percent, P x Mz = 43 percent, P x Ap = 52 percent P x Ap x Mz = 81 percent, Ap x Mz = 92 percent.

5. The within-species variation of ponderosa is still a question. Wind-pollinated seeds from three different trees within the same forest plot were planted in close proximity to each other in the nursery. The mortality of the progeny, (table 2...2b, 3b, and 4b plus 5b) is 54 percent, 28 percent, and 23 percent, respectively. This might indicate that the one tree produces more susceptible offspring. On the other hand, 4a and 5a, with 13 percent and 31 percent respectively, illustrate differences in mortality in the same seedlings in different nursery locations. Thus within-species variation and erratic weevil population prevent a reasonably reliable interpretation of the results outside the cage.

6. Some indication of the role of the Jeffrey maternal parent in resistance may be found in table 3. The same pollen (J x Cl) was used on three different Jeffreys. The mortality varied from about 10 percent to 20 percent. (These plants are included in the 1957 forced-attack tests and another season's attack may change the results.)

7. When Apache is introduced into Jeffrey, the hybrid is much less resistant than Jeffrey (table 3, block 2). This is similar to the decrease which takes place when Apache is crossed with ponderosa.

8. The lodgepole x jack hybrid in table 2, block 6, has been suggested for Christmas tree plantings. These results indicate that there might be need for weevil control in such plantings.

9. Block 3 and 4 of table 3 is a striking illustration of the effect of certain crosses. Nigracalabrica is rather resistant; but when crossed with thumbergii, the hybrid is highly susceptible.

As a result of the season's work, three general points are emphasized. First, it is important to continue screening various hybrids for resistance. Second, the spotty character of the natural infestation suggests the advisability of devoting more work to forced attacks. Third, though the randomized rows are fairly suitable, randomization of plants within rows would be desirable.

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